On the interaction between marine boundary layer cellular cloudiness and surface heat fluxes

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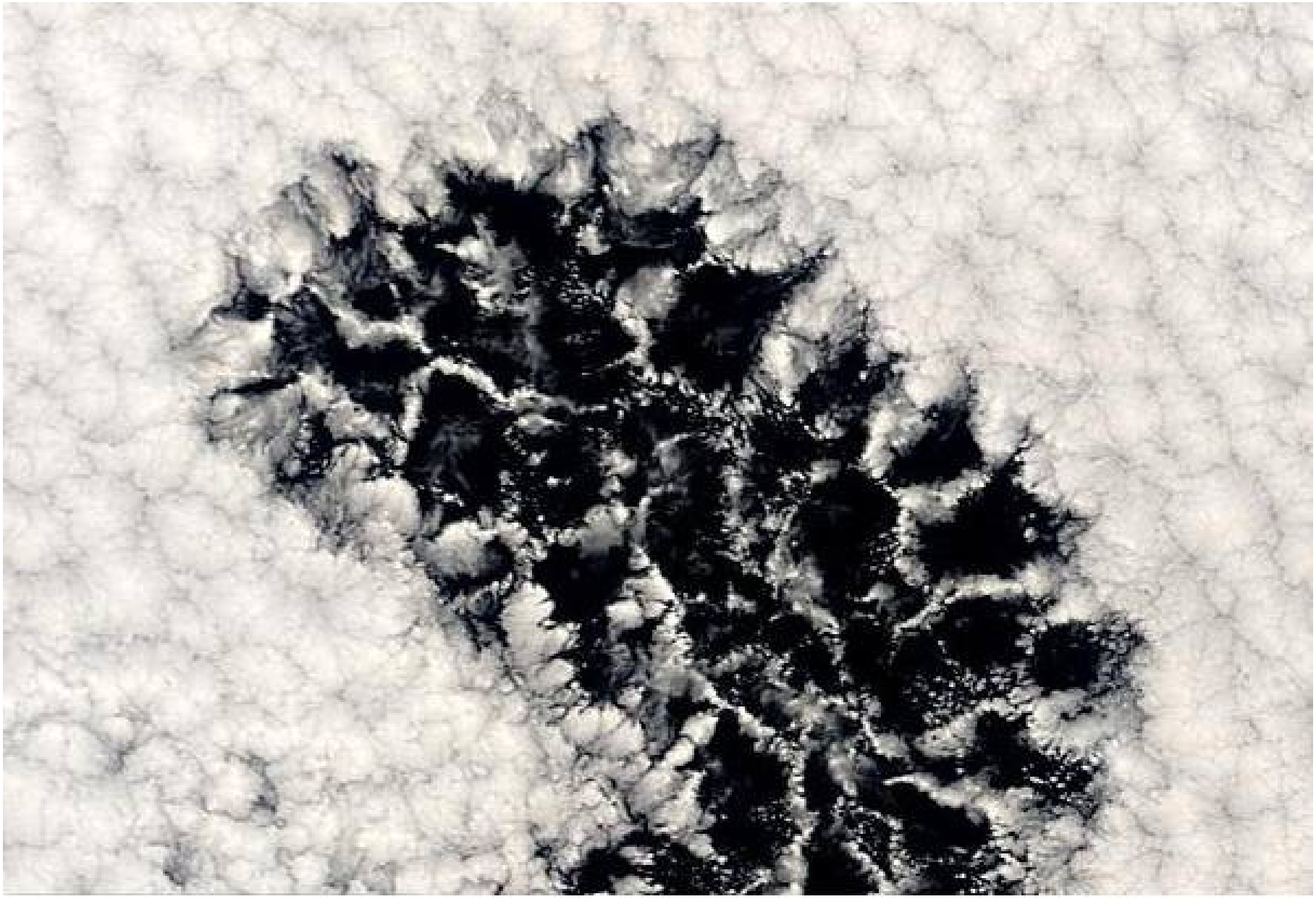
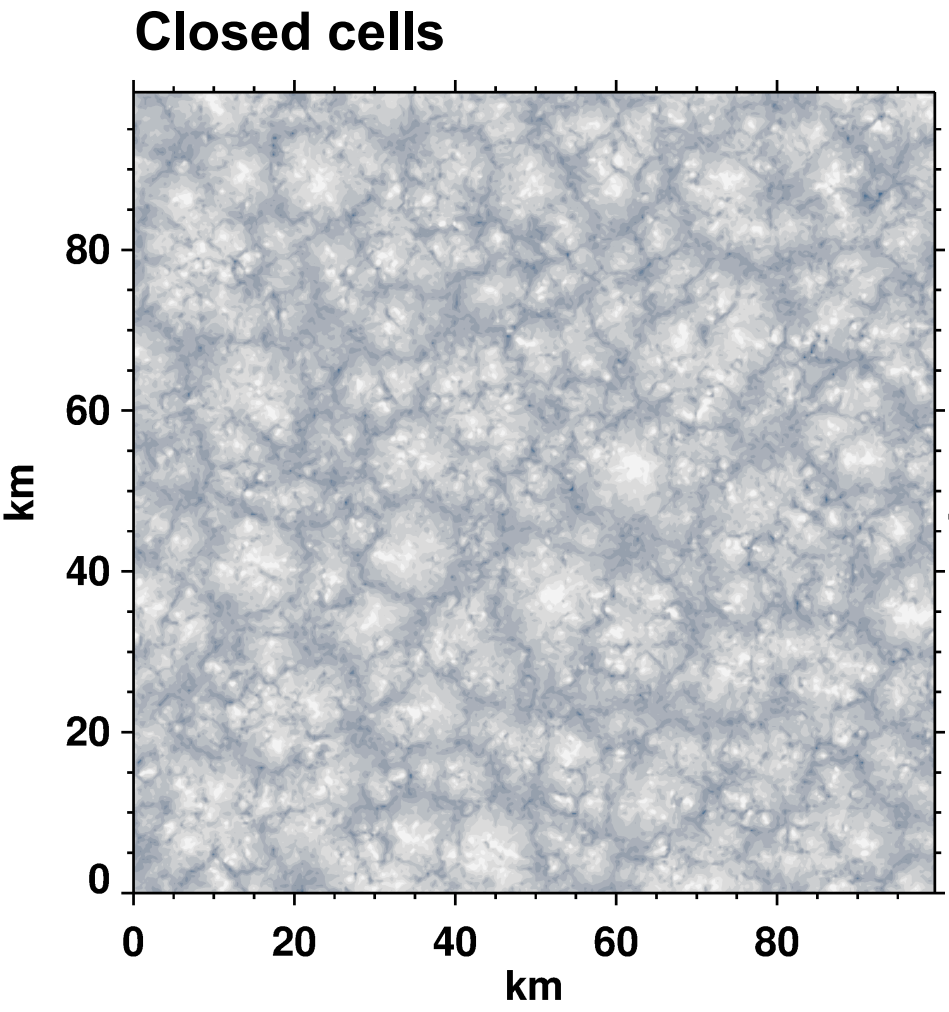
Closed- and open cells

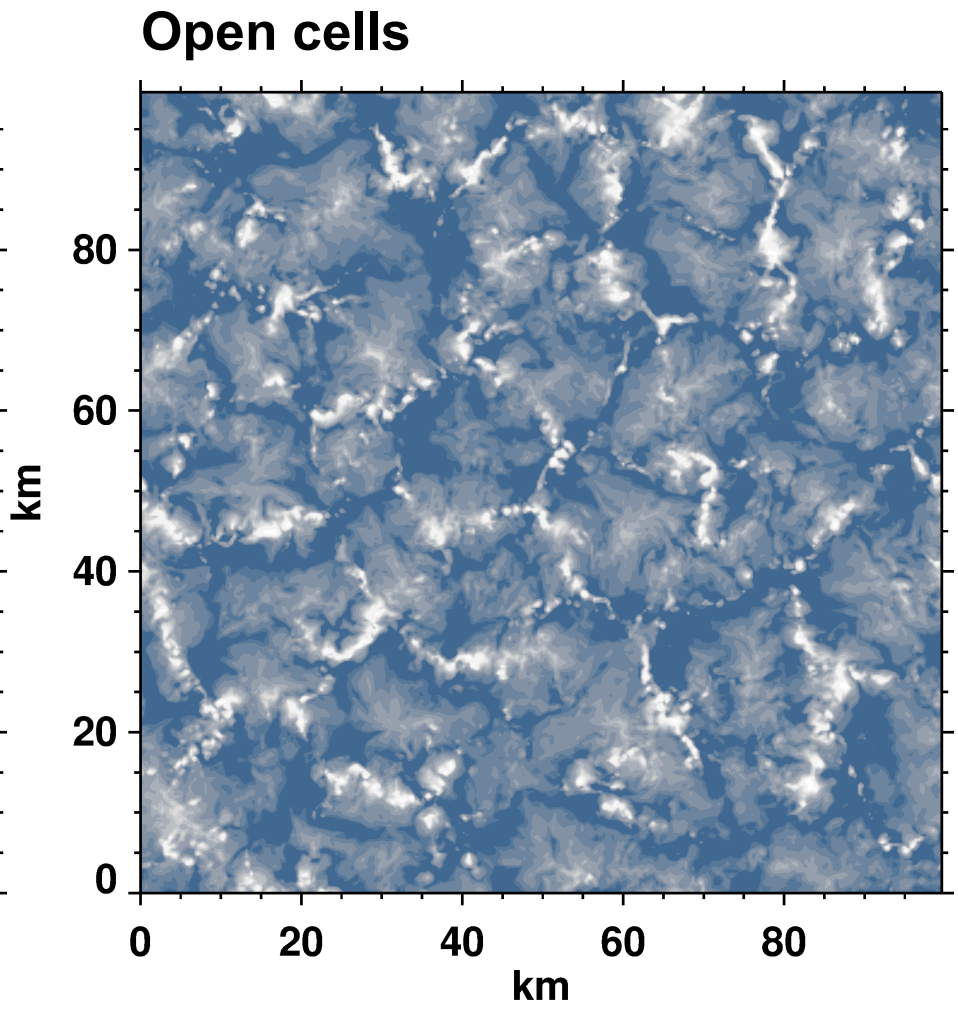


Outline

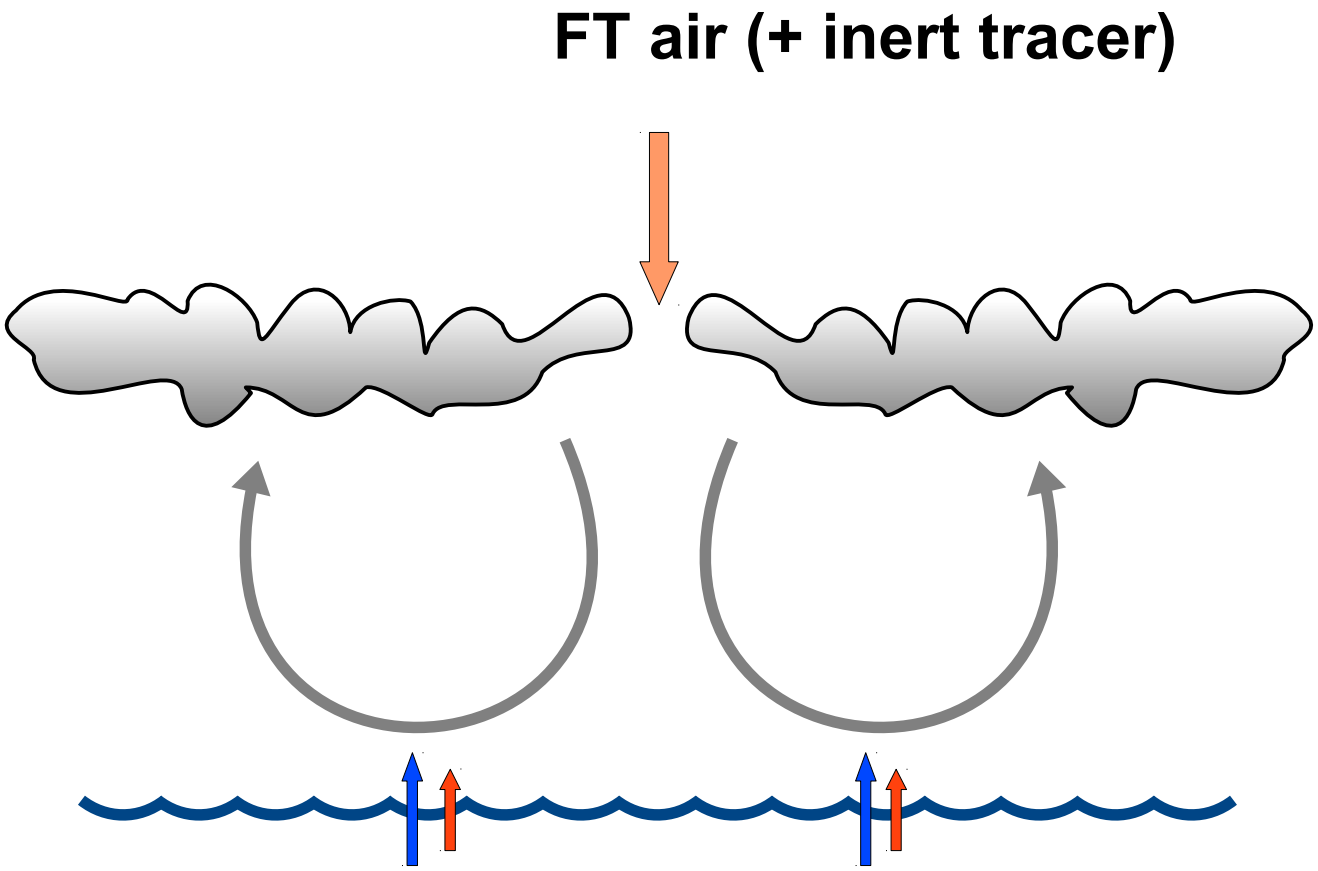
- **Do cellular cloud states shape surface heat fluxes?**
- **Do the surface heat fluxes feed back to the cellular state?**
  - **(Specifically: In the open-cell state?)**
- **WRF(/Chem)**
  - **Low geostrophic wind speed (1.4 m s^{-1})**
  - **Perpetual night**
- **Insights**
  - **into the “mechanics” of the cloudy MBL**
  - **for global modeling**

Simulations

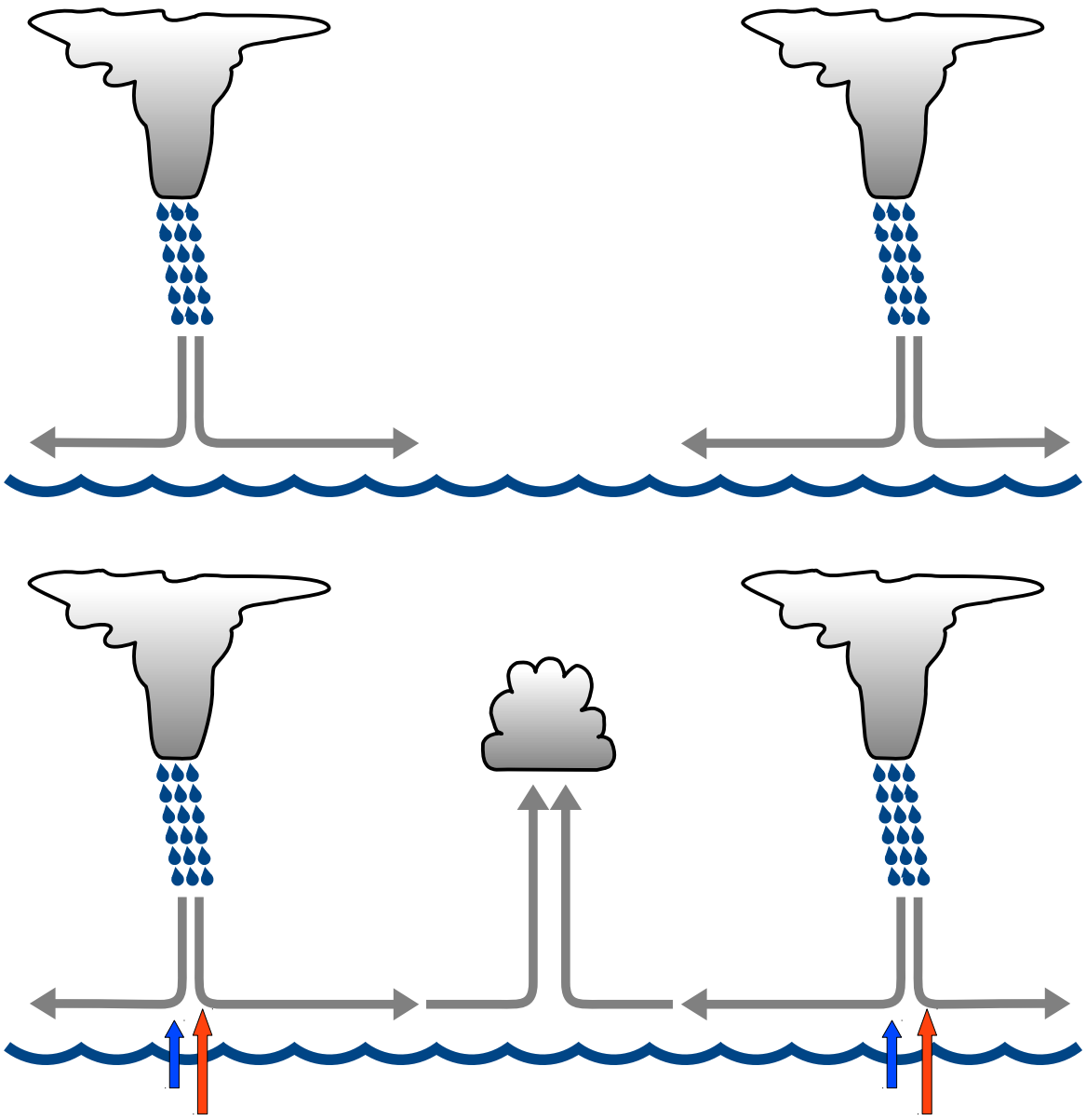




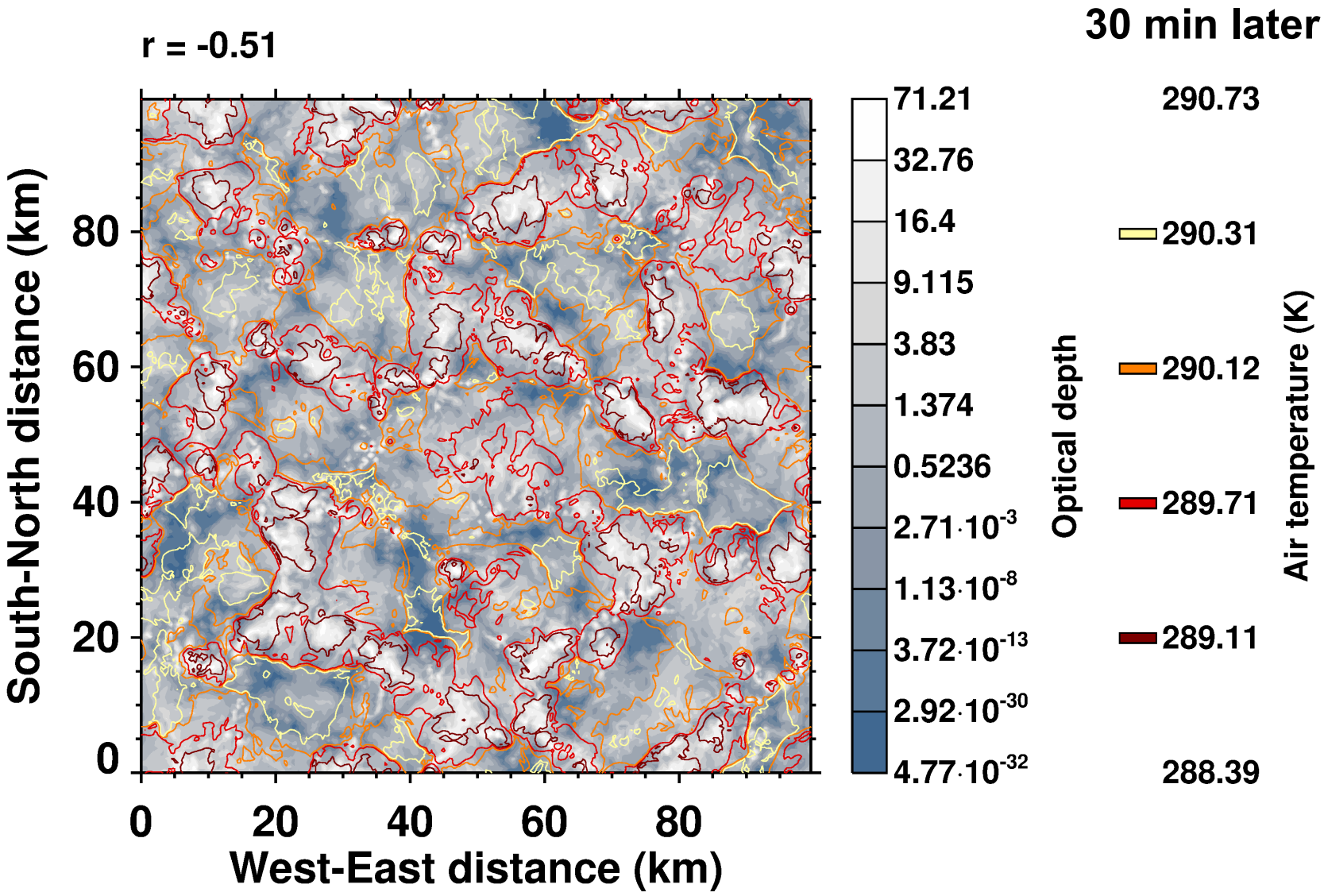
Closed cells



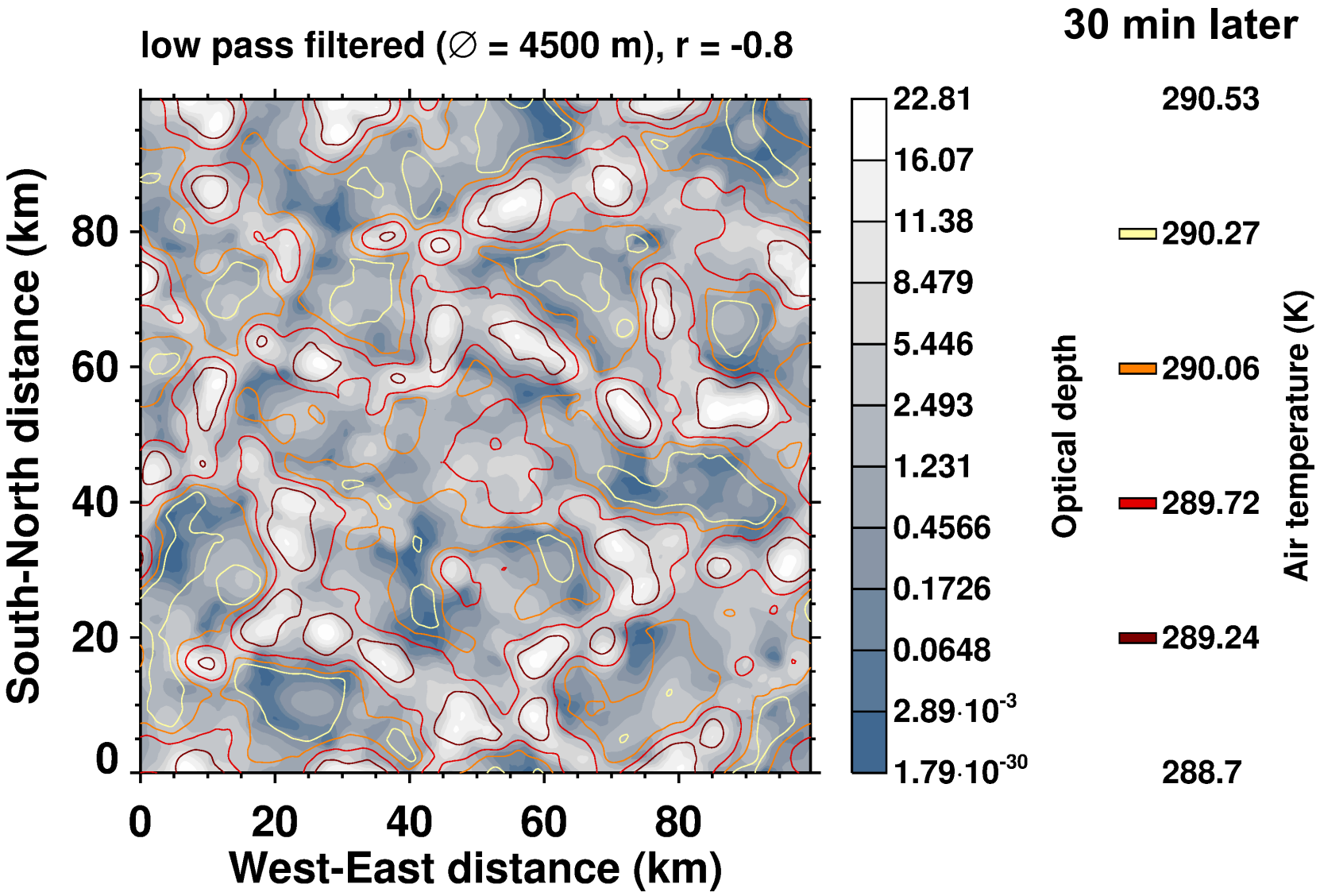
Open cells



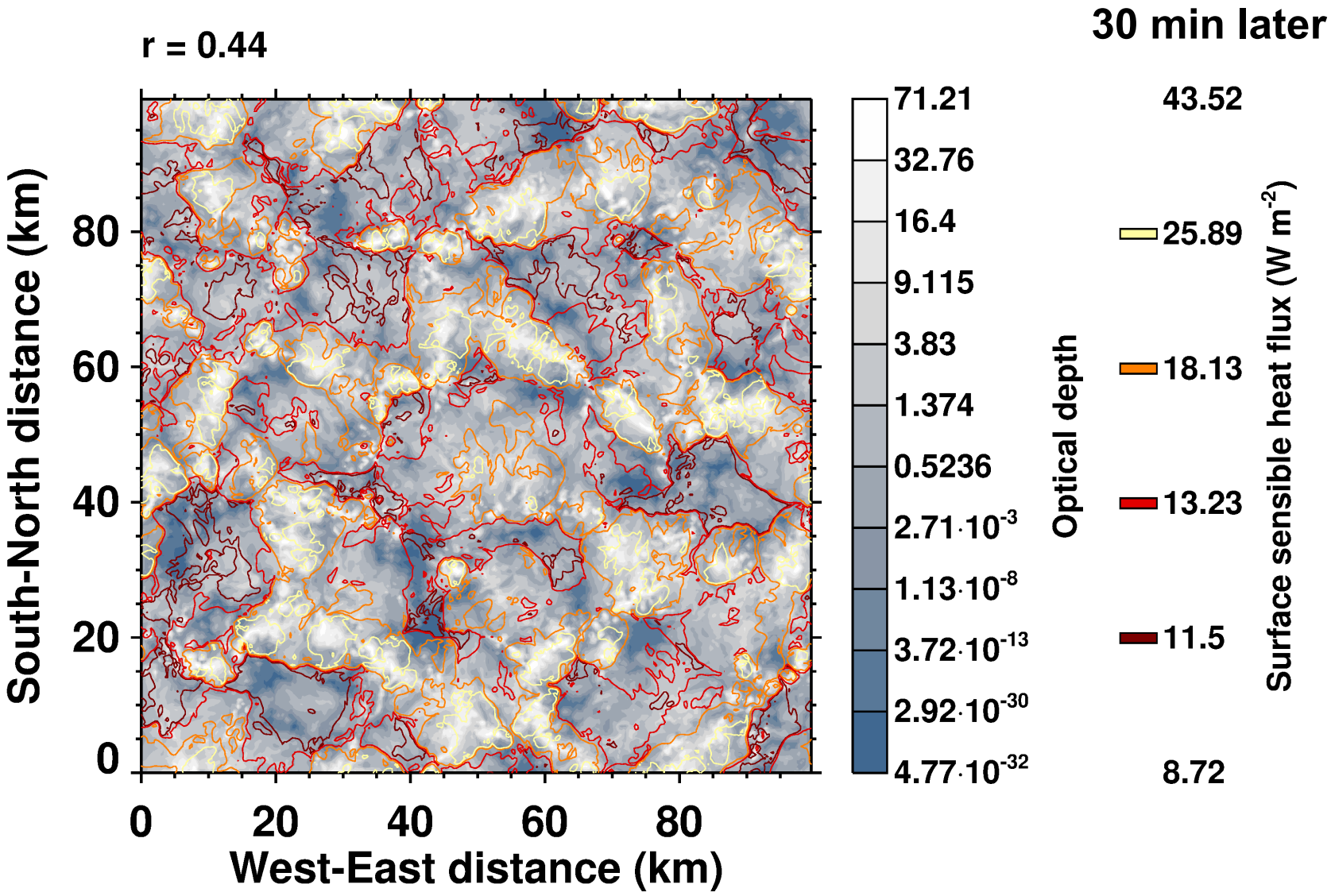
Open cells – surface air temperature



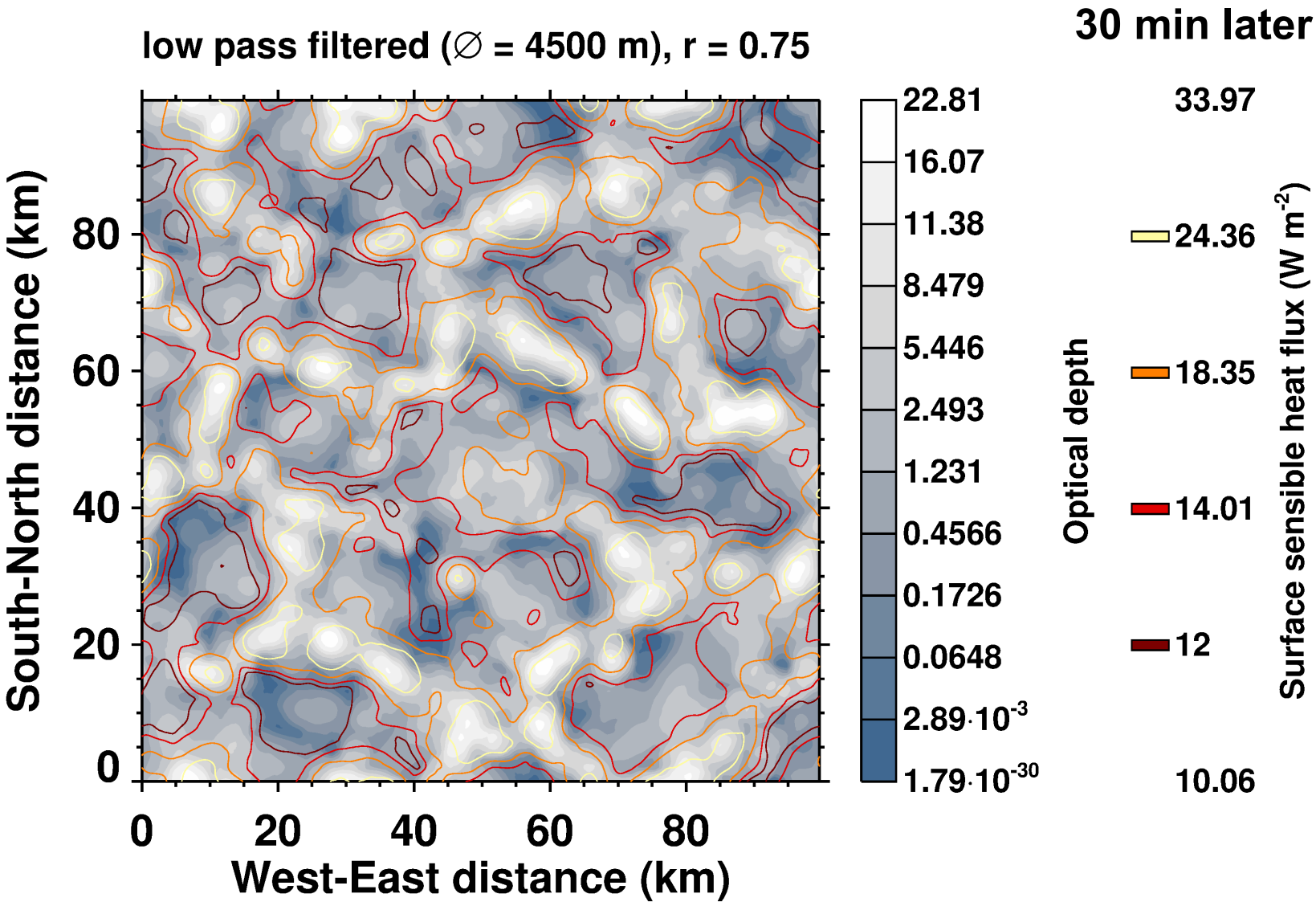
Open cells – surface air temperature



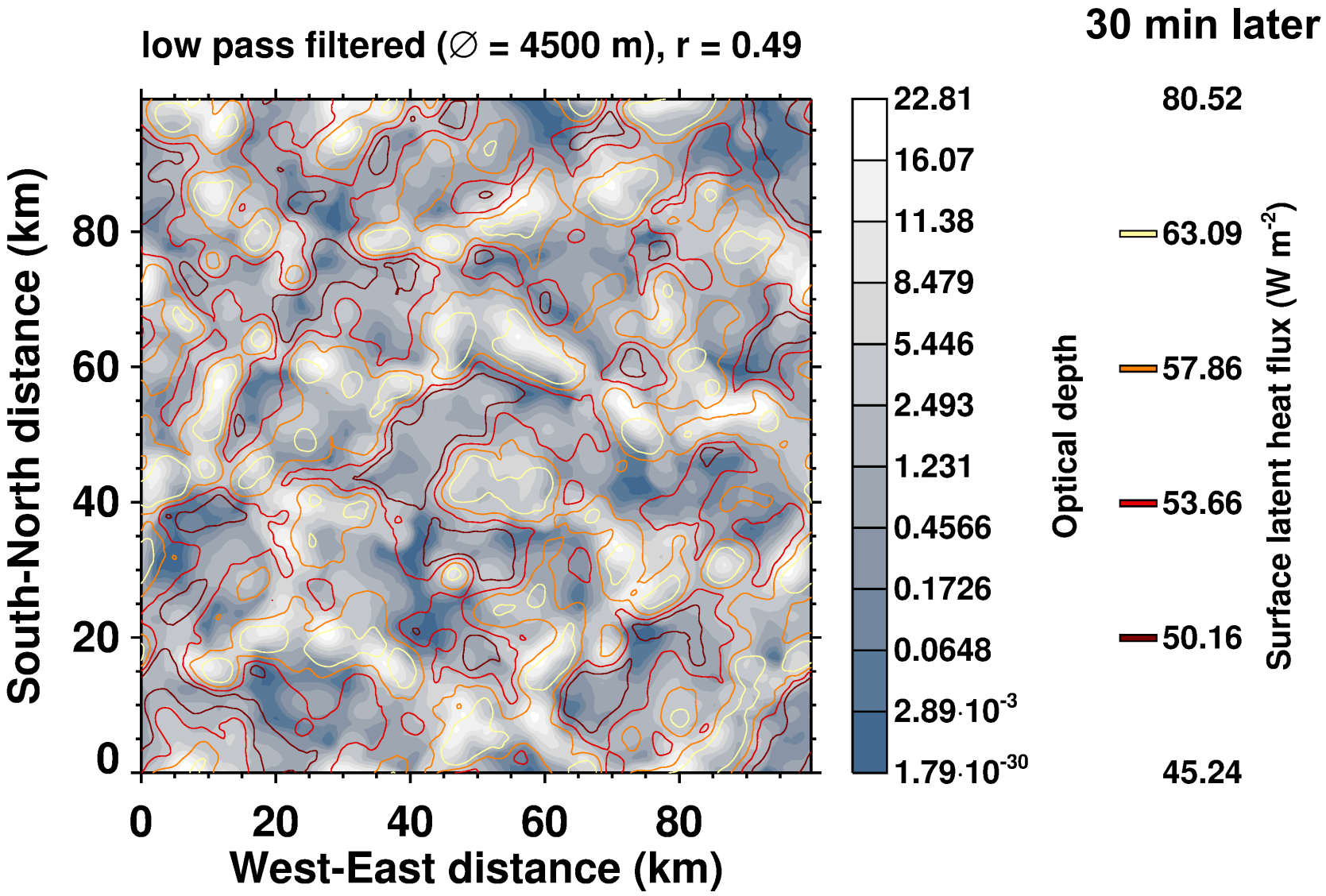
Open cells – surface sensible heat flux



Open cells – surface sensible heat flux



Open cells – surface latent heat flux



Open cells

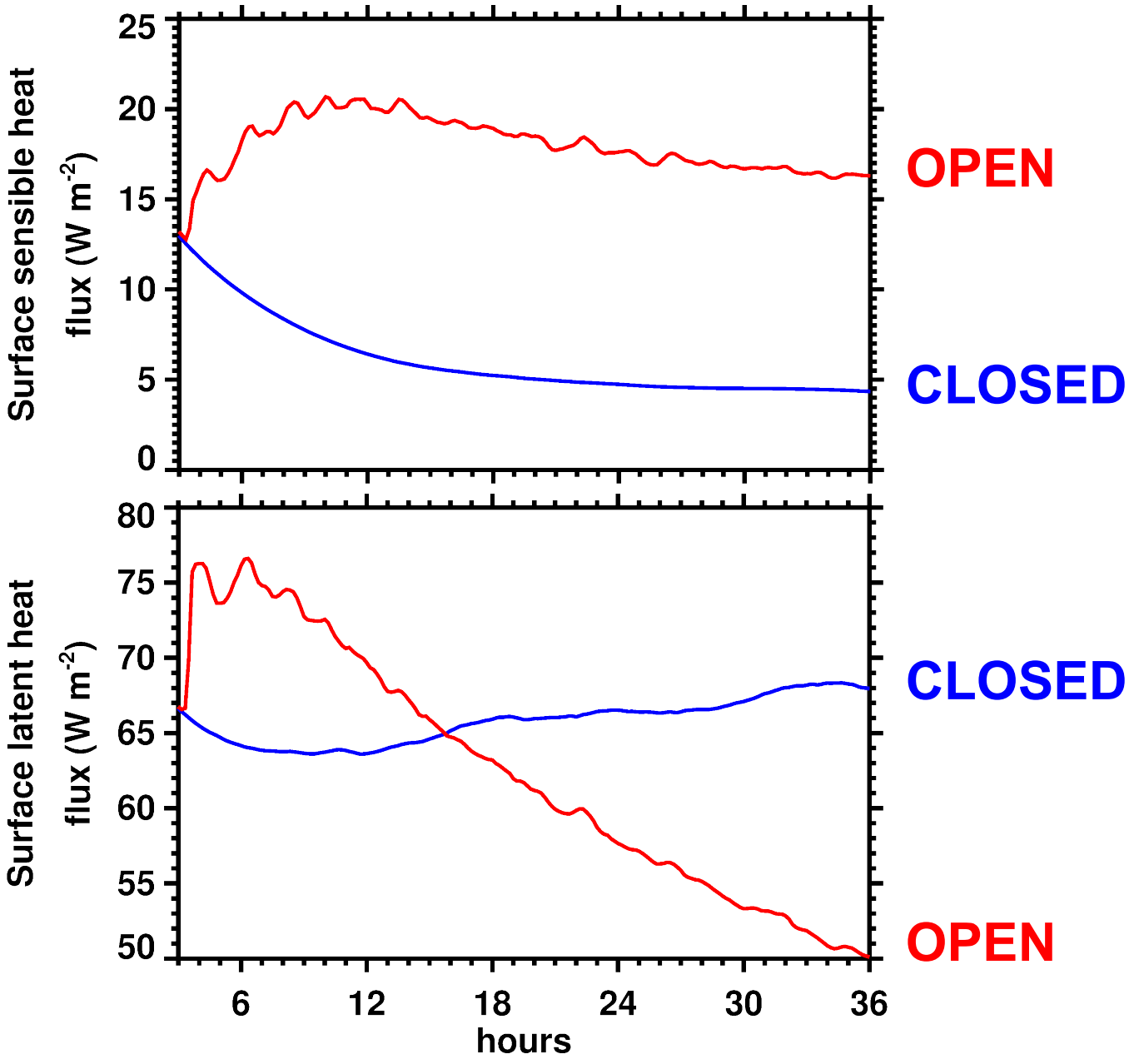
- **Horizontal spatial structure of the open-cell state**
  - ➔**Imprint on surface temperature, sensible heat flux**
  - ➔**Less pronounced for surface latent heat flux**

- **Mechanism:**
  - **Precipitation, cold downdrafts, cold pools**

- **Cloud optical depth predicts distribution of surface quantities with a lead time of ~ 30 min**

- **(Low wind speed)**

Surface flux feedback to the open-cell state

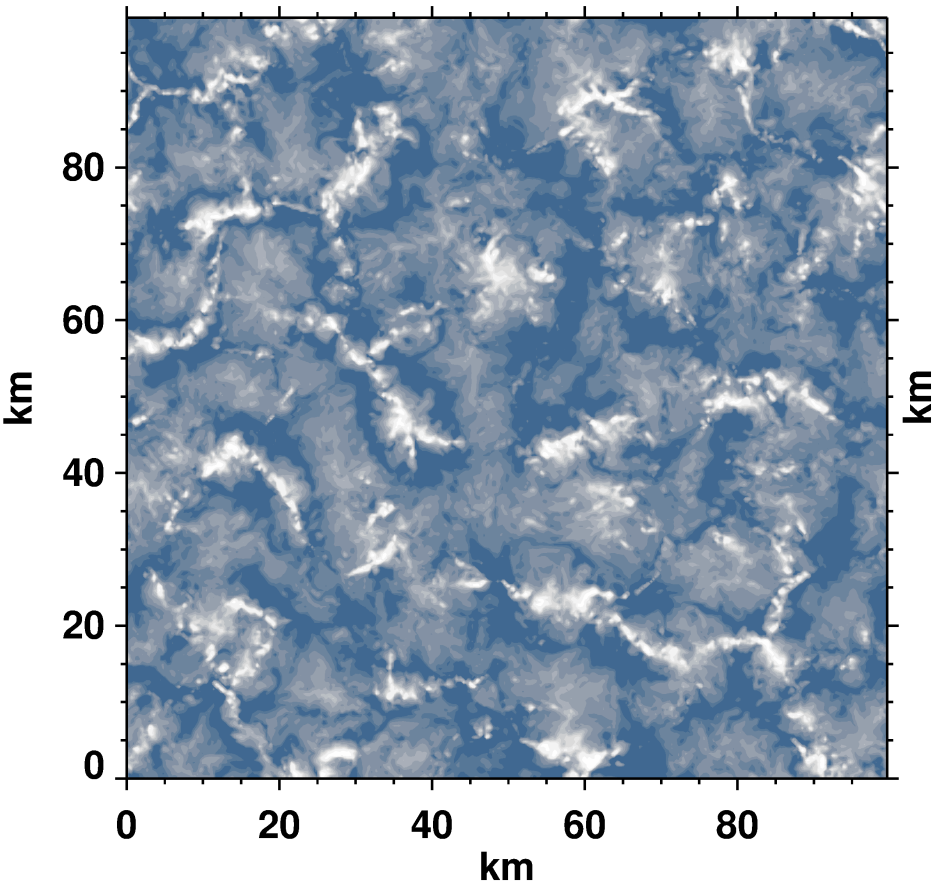


Surface flux feedback to the open-cell state

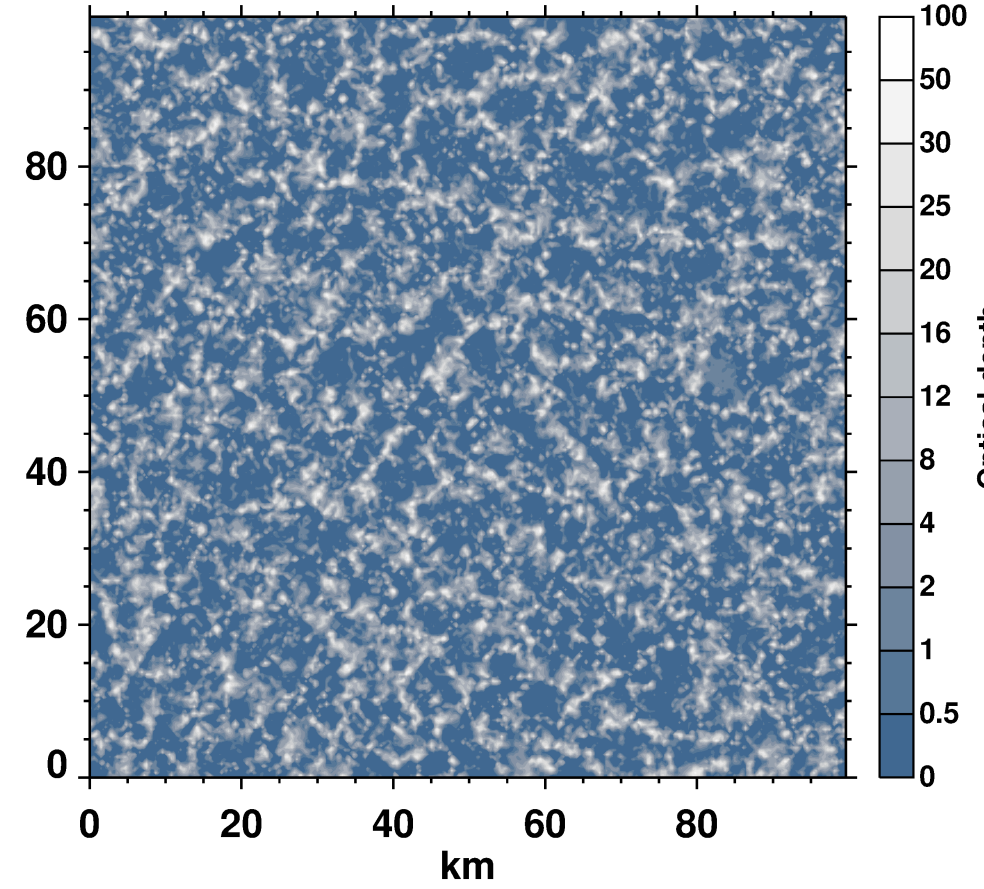
- ➔ Open-cell simulation
- ➔ Prescribe surface heat fluxes from closed-cell state

Surface flux feedback to the open-cell state

→ Collapse

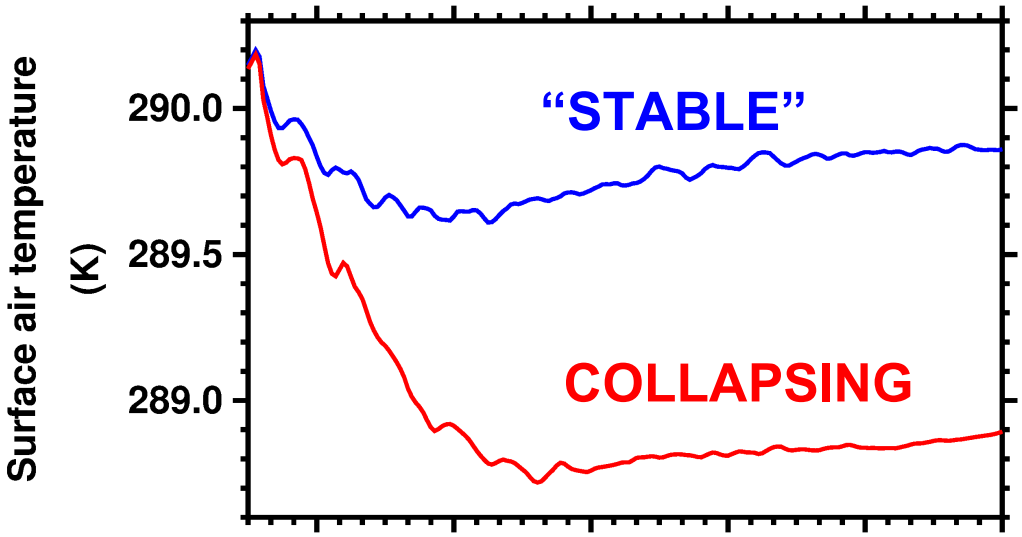


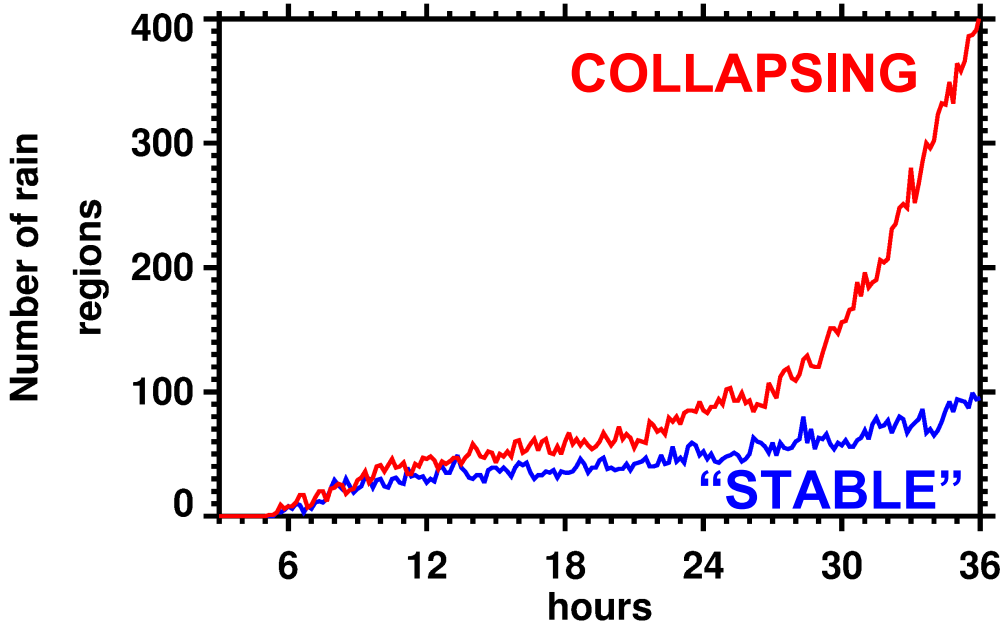
12 h



24 h

Surface flux feedback to the open-cell state





Surface flux feedback to the open-cell state

- ➔ **The open-cell state creates conditions that are conducive to its maintenance**
- ➔ **Specifically, the enhanced surface sensible heat flux in the open-cell state extends its lifetime**

Sub-gridscale variability

- **No sub-grid variability of the surface heat fluxes in global models**
  - **Does this matter?**

➔ **Homogenize surface heat fluxes**

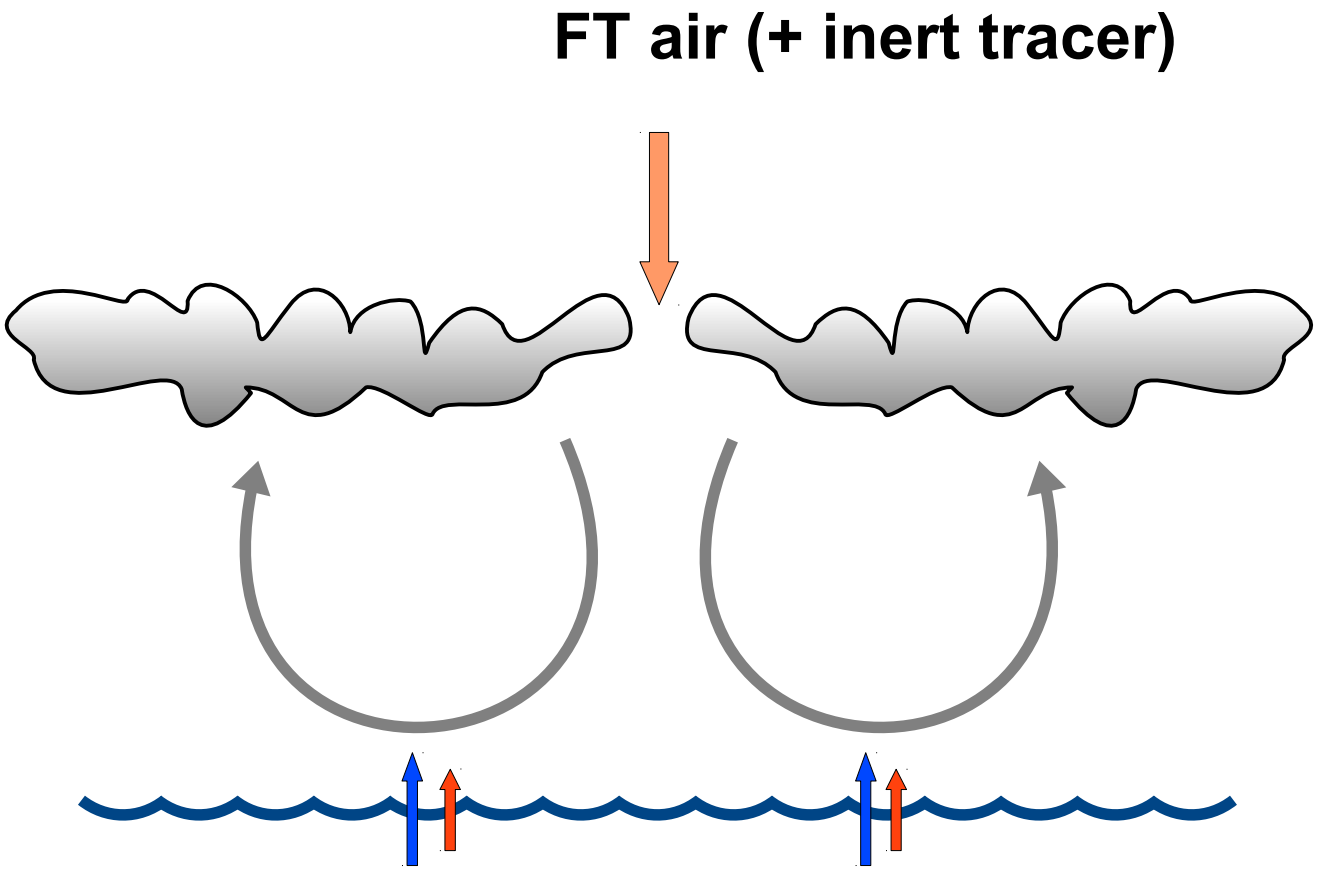
- **Closed-cell state**
- **Open-cell state**

➔ **Very small effect on cloud properties in the considered cases**

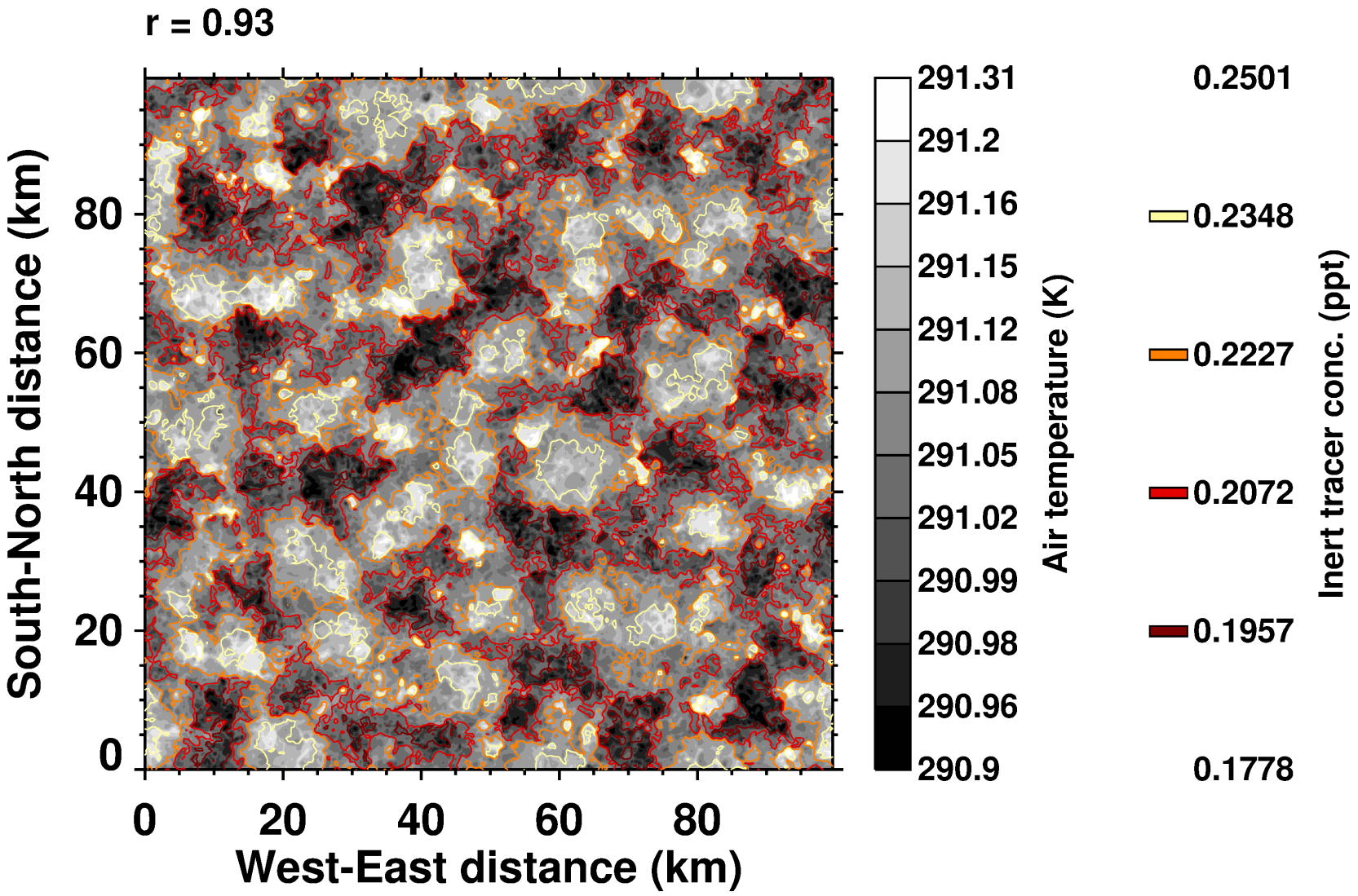
- **Similar result obtained by Seifert and Heus (ACP, 2013) for trade wind cumuli**

➔ **Global models need not to represent sub-gridscale variability in surface heat fluxes**

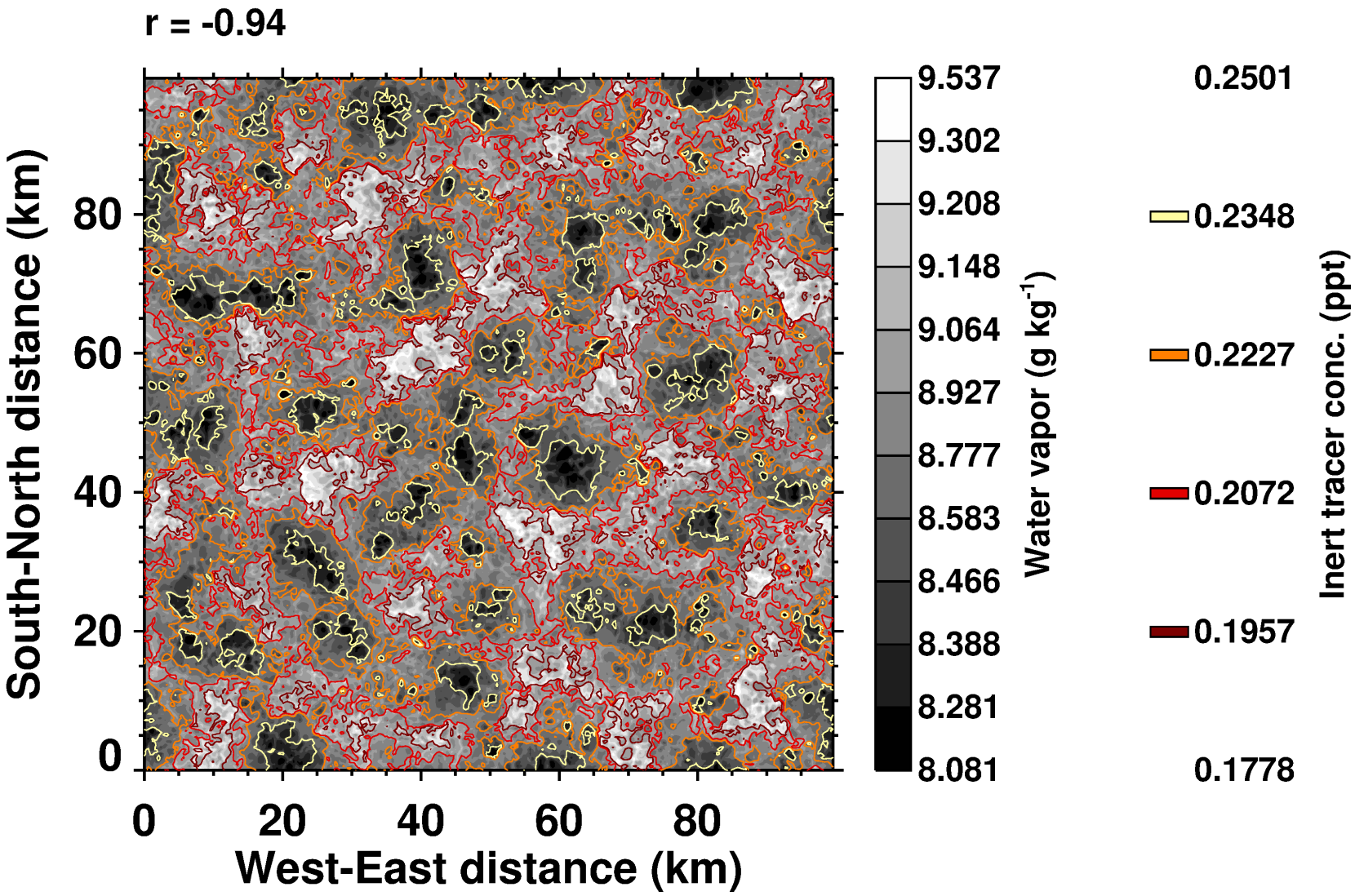
Closed cells



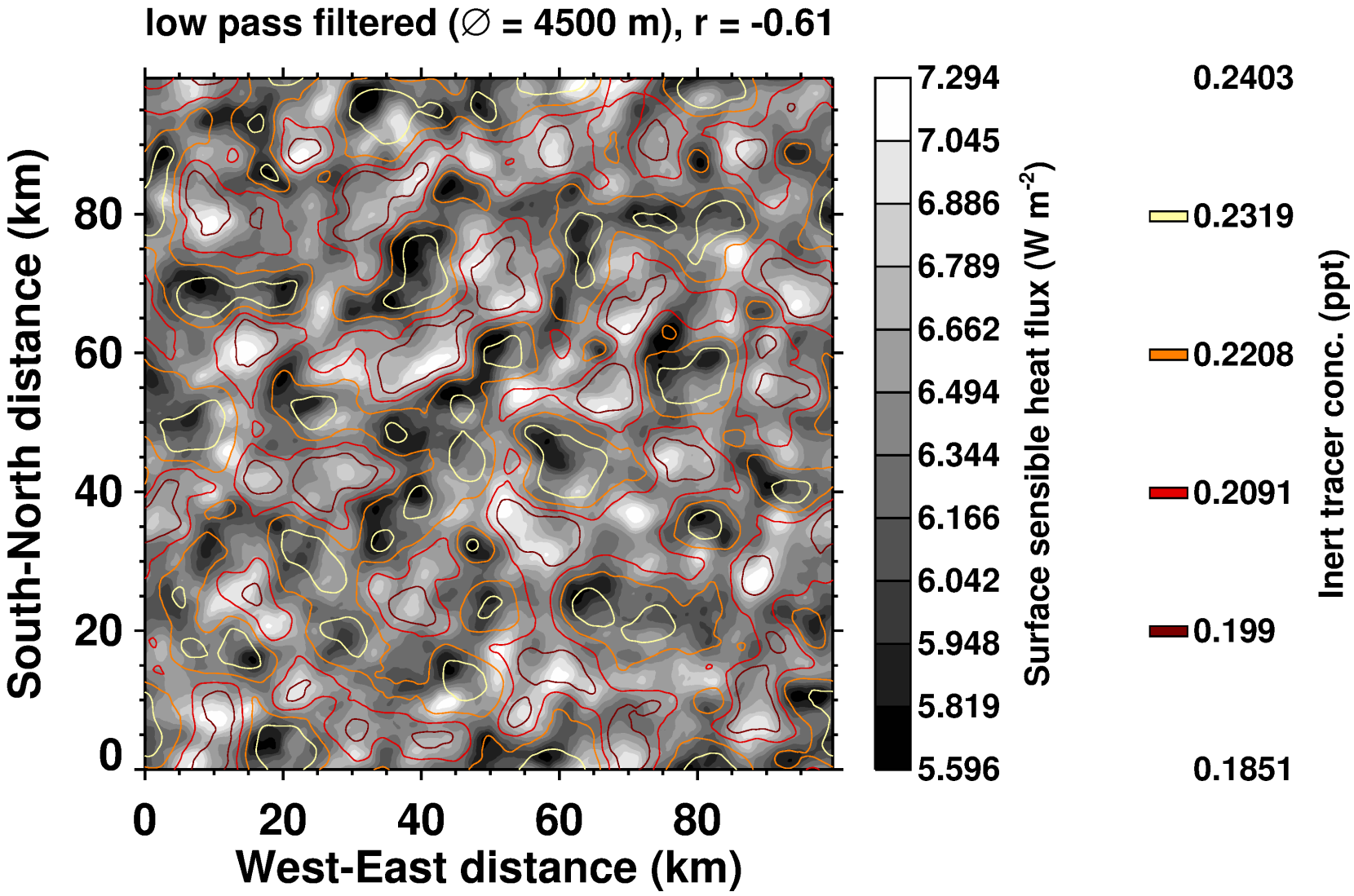
Closed cells – surface air temperature



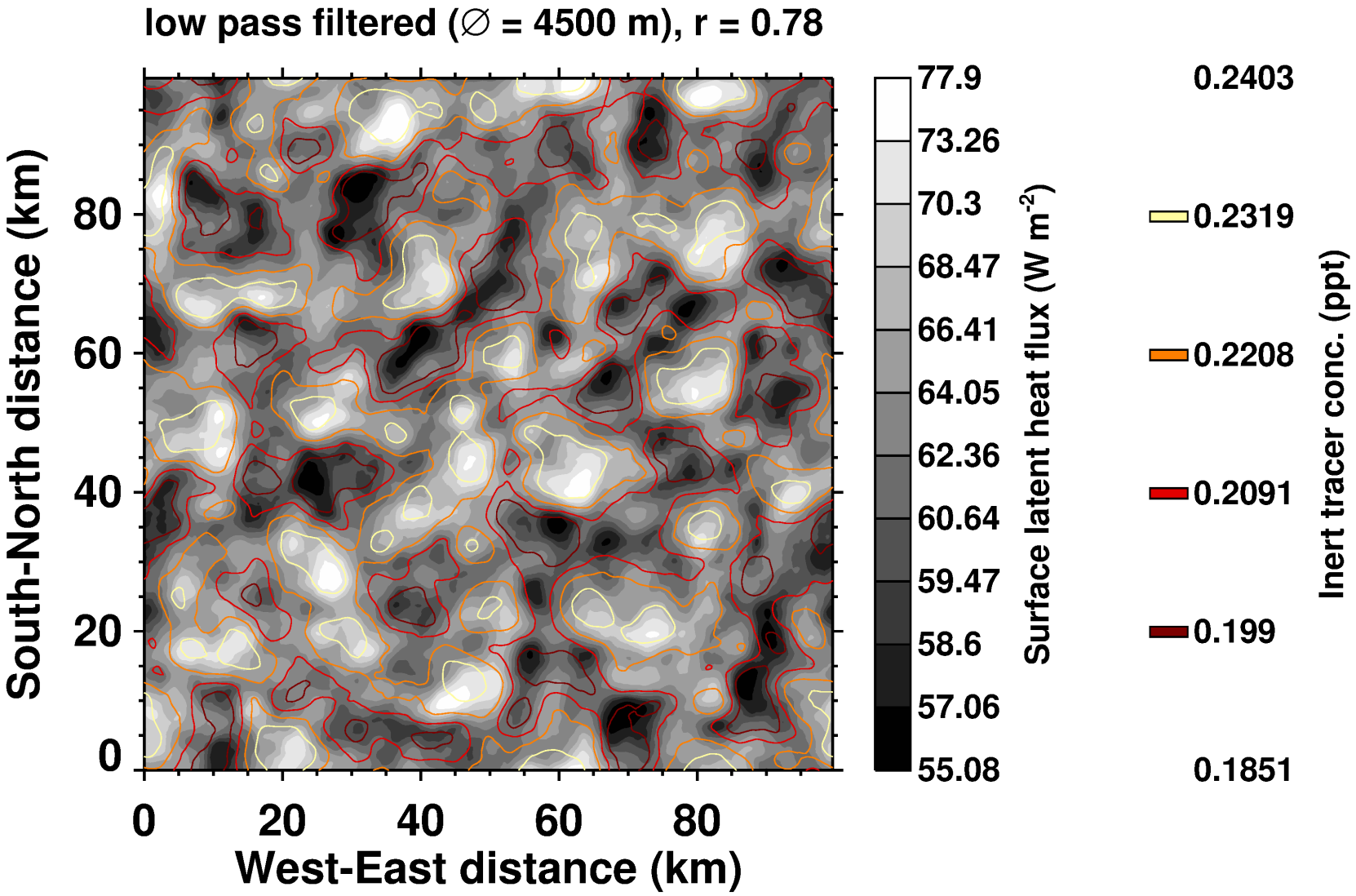
Closed cells – surface water vapor



Closed cells – surface sensible heat flux



Closed cells – surface latent heat flux



Closed cells

- Horizontal spatial structure of the closed-cell state
  - ➔Imprint on surface temperature / water vapor
  - ➔Surface heat fluxes
- Entrainment of dry/warm air into the boundary layer
  - Suppresses sensible heat flux
  - Promotes latent heat flux
- (30 m vertical resolution ... over-entrainment?)